

PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Application No.: 10/789,940

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Applicant: Osamu Shinkawa et al.

Group Art Unit: 2861

Examiner: Jannelle M. Lebron

Title: DROPLET EJECTING APPARATUS AND EJECTION
ABNORMALITY DETECTING/DETERMINING METHOD
FOR A DROPLET EJECTING HEAD

Attorney Docket: 9319S-000656

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

AMENDMENT

Sir:

In response to the Office Action mailed February 10, 2006, please amend the application as follows and consider the remarks set forth below.

Amendments to the Claims begin on page 2 of this paper.

Remarks begin on page 8 of this paper.

AMENDMENTS TO THE CLAIMS

The following listing of claims will replace all prior versions and listings of claims in the application.

LISTING OF CLAIMS

1. (Currently Amended) A droplet ejecting apparatus comprising:
a droplet ejecting head including:
 a vibration plate;
 an actuator for displacing the vibration plate;
 a cavity filled with a liquid and having an interior pressure to be increased and decreased by a displacement of the vibration plate; and
 a nozzle communicating with the cavity and for ejecting the liquid as a droplet depending upon an increase and decrease of the pressure within the cavity;
 a drive circuit for driving the actuator; and
 an ejection abnormality detecting device having a residual vibration detecting device for detecting residual vibration of the vibration plate displaced by the actuator after the actuator is driven by the drive circuit, to detect an abnormality of droplet ejection depending upon a vibration pattern of the residual vibration of the vibration plate detected by the residual vibration detecting device, the ejection abnormality detecting device including a determining device for determining a presence or absence of a droplet ejection abnormality of the droplet ejection head depending upon the vibration pattern of residual vibration of the vibration plate;
 wherein the determining device determines a cause of the ejection abnormality when the presence of a droplet ejection abnormality is determined;

wherein the vibration pattern of the residual vibration of the vibration plate includes a period of the residual vibration; and

wherein, when the period of the residual vibration of the vibration plate is shorter than a predetermined first period, the determining device determines that the cause of the droplet ejection abnormality is that there is an air bubble mixed in the cavity.

2-5. (Cancelled)

6. (Currently Amended) The droplet ejecting apparatus according to claim 51, wherein, when the period of the residual vibration of the vibration plate is longer than a predetermined second period but shorter than a predetermined third period, the determining device determines that the cause of the droplet ejection abnormality is that there is paper powder adhered to a vicinity of an exit of the nozzle, wherein the second period is longer than the first period and the third period is longer than the second period.

7. (Original) The droplet ejecting apparatus according to claim 6, wherein, when the period of the residual vibration of the vibration plate is longer than said predetermined third period, the determining device determines that the cause of the droplet ejection abnormality is that there is a thickened liquid in a vicinity of the nozzle.

8. (Currently Amended) The droplet ejecting apparatus according to claim 21, further comprising a storage device for storing a result of the determination made by the determining device.

9. (Original) The droplet ejecting apparatus according to claim 1, further comprising a switch device for switching, after a droplet ejecting operation by the actuator, the actuator from the drive circuit to the ejection abnormality detecting device.

10. (Original) The droplet ejecting apparatus according to claim 1, wherein the residual vibration detecting device has an oscillation circuit, the oscillation circuit oscillating based on a capacitance component of the actuator varying depending upon the residual vibration of the vibration plate.

11. (Original) The droplet ejecting apparatus according to claim 10, wherein the oscillation circuit comprises a CR oscillation circuit having a capacitance component of the actuator and a resistance component of a resistance element connected to the actuator.

12. (Original) The droplet ejecting apparatus according to claim 10, wherein the oscillation circuit has an oscillation frequency configured one figure higher than a vibration frequency of the residual vibration of the vibration plate.

13. (Original) The droplet ejecting apparatus according to claim 10, wherein the residual vibration detecting device includes an F/V conversion circuit for

generating a voltage waveform of the residual vibration of the vibration plate from a predetermined signal group generated based on an oscillation frequency change in an output signal of the oscillation circuit.

14. (Original) The droplet ejecting apparatus according to claim 13, wherein the residual vibration detecting device includes a waveform shaping circuit for shaping a voltage waveform of the residual vibration of the vibration plate generated by the F/V conversion circuit into a predetermined waveform.

15. (Original) The droplet ejecting apparatus according to claim 14, wherein the waveform shaping circuit includes a DC component removing device for removing a direct-current component from a voltage waveform of the residual vibration of the vibration plate generated by the F/V conversion circuit, and a comparator for comparing between a voltage waveform removed from the direct-current component by the DC component removing device and a predetermined voltage value, the comparator generating and outputting a rectangular wave depending upon the voltage comparison.

16. (Original) The droplet ejecting apparatus according to claim 15, wherein the ejection abnormality detecting device includes a measuring device for measuring a period of the residual vibration of the vibration plate from the rectangular wave generated by the residual vibration detecting device.

17. (Original) The droplet ejecting apparatus according claim 16, wherein the measuring device has a counter, the counter counting pulses of a reference signal to thereby measure a time between at least one of rising edges of the rectangular waves, and rising and falling edges of the rectangular waves.

18. (Original) The droplet ejecting apparatus according to claim 1, wherein the actuator comprises an electrostatic actuator.

19. (Original) The droplet ejecting apparatus according to claim 1, wherein the actuator comprises a piezoelectric actuator utilizing a piezoelectric effect of a piezoelectric element.

20. (Currently Amended) A droplet ejecting head ejection abnormality detecting/determining method comprising the steps of:

detecting residual vibration of a vibration plate after carrying out an operation for ejecting a liquid within a cavity as a droplet from a nozzle by driving an actuator to vibrate the vibration plate;

detecting a droplet ejection abnormality; and

determining a cause of the droplet ejection abnormality depending upon a detected vibration pattern of the residual vibration of the vibration plate the vibration pattern of the residual vibration of the vibration plate including a period of the residual vibration:

determining that the cause of the droplet ejection abnormality is that there is an air bubble mixed in the cavity when the period of the residual vibration of the vibration plate is shorter than a predetermined first period;

determining that the cause of the droplet ejection abnormality is that there is paper powder adhered to a vicinity of an exit of the nozzle when the period of the residual vibration of the vibration plate is longer than a predetermined second period but shorter than a predetermined third period, wherein the second period is longer than the first period and the third period is longer than the second period.

determining that the cause of the droplet ejection abnormality is that there is a thickened liquid in a vicinity of the nozzle when the period of the residual vibration of the vibration plate is longer than said predetermined third period.

REMARKS

Claims 1 and 6-20 are now pending in the application. By this paper, Claims 1, 6, 8, and 20 have been amended and Claims 2-5 have been cancelled without prejudice or disclaimer of the subject matter contained therein. The basis for these amendments can be found throughout the specification, claims, and drawings originally filed. No new matter has been added. The preceding amendments and the following remarks are believed to be fully responsive to the outstanding Office Action and are believed to place the application in condition for allowance.

The Examiner is respectfully requested to reconsider and withdraw the rejections in view of the amendments and remarks contained herein.

REJECTION UNDER 35 U.S.C. § 102

Claims 1-4, 8-11, 13-14, and 18-20 stand rejected under 35 U.S.C. § 102(b) as being anticipated by Kanayama (U.S. Pat. No. 4,498,088).

This rejection is respectfully traversed.

Applicants respectfully submit that this rejection is moot as independent Claims 1 and 20 have been amended to include allowable subject matter. Specifically, independent Claim 1 has been amended to include the subject matter of Claims 2-5 and independent Claim 20 has been amended to include the subject matter of Claims 4-7. Accordingly, Applicants respectfully submit that independent Claims 1 and 20, as well as Claims 6-19, respectively dependent therefrom, are in condition for allowance. Accordingly, reconsideration and withdraw of the rejections is respectfully requested.

ALLOWABLE SUBJECT MATTER

The Examiner states that Claims 5-7, 12, and 15-17 would be allowable if rewritten in independent form. Accordingly, Applicants have amended independent Claim 1 to include the allowable subject matter of Claim 5 by incorporating Claims 2-5 therein. In addition, Applicants have amended independent Claim 20 to include the subject of Claim 4 as well as the allowable subject matter of Claims 5-7. Accordingly, Applicant respectfully submits that independent Claims 1 and 20, as well as Claims 6-19, respectively dependent therefrom, are in condition for allowance.

CONCLUSION

It is believed that all of the stated grounds of rejection have been properly traversed, accommodated, or rendered moot. Applicant therefore respectfully requests that the Examiner reconsider and withdraw all presently outstanding rejections. It is believed that a full and complete response has been made to the outstanding Office Action and the present application is in condition for allowance. Thus, prompt and favorable consideration of this amendment is respectfully requested. If the Examiner believes that personal communication will expedite prosecution of this application, the Examiner is invited to telephone the undersigned at (248) 641-1600.

Respectfully submitted,

Dated: May 9, 2006

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